What is claimed is:

1. A method for manufacturing a control rod for boiling water reactor, the control rod comprising a tie rod having a cruciform cross section, a handle attached to an axially upper part of the tie rod, a lower part support member or a velocity limiter attached to an axially lower part of the tie rod, and sheaths attached to tips of cruciform arms of the tie rod, each of sheaths having a U-shaped cross section, comprising the steps of:

forming the tie rod which is provided with steps for fixing the sheaths at the tips of the cruciform arms;

fitting the tips of each of the sheaths onto the steps of the tie rod; and

fixing each of the sheaths to the tie rod by performing a laser welding with the sheath being fitted onto the tie rod, wherein a surface to be welded is irradiated with a YAG laser beam or a CO_2 laser beam in such a manner that an axial center position of the beam is shifted from an end face position of the step of the tie rod at least toward an axis center of the tie rod to achieve a continuous weld of at least a part of the tie rod in a longitudinal direction thereof.

2. A method for manufacturing a control rod for boiling water reactor, the control rod comprising a tie rod

having a cruciform cross section, a handle attached to an axially upper part of the tie rod, a lower part support member or a velocity limiter attached to an axially lower part of the tie rod, and sheaths attached to tips of cruciform arms of the tie rod, each of sheaths having a U-shaped cross section, comprising the steps of:

forming the tie rod which is provided with steps for fixing the sheaths at the tips of the cruciform arms by a drawing process;

fitting the tips of each of the sheaths onto the steps of the tie rod; and

fitting both of tips of the U-shape of each of the sheaths onto the steps of the tie rod; and

fixing each of the sheaths to the tie rod by performing a laser welding with the sheath being fitted onto the tie rod, wherein a surface to be welded is irradiated with a YAG laser beam or a CO_2 laser beam in such a manner as to achieve a continuous weld of at least a part of the tie rod in a longitudinal direction thereof.

3. The method for manufacturing a control rod for boiling water reactor according to claim 2, wherein the laser welding is performed in a state set so that an axial center position of the beam is shifted from an end face position of the step of the tie rod at least toward an axis center of the tie rod.

4. A method for manufacturing a control rod for boiling water reactor, the control rod comprising a tie rod having a cruciform cross section, a handle attached to an axially upper part of the tie rod, a lower part support member or a velocity limiter attached to an axially lower part of the tie rod, and sheaths attached to a lower end of the handle, comprising the steps of:

forming a step for fixing the sheaths on the lower end of the handle;

fitting an upper edge of each of the sheaths onto the step of the handle; and

fixing each of the sheaths to the handle by performing a laser welding with the sheath being fitted onto the handle, wherein a surface to be welded is irradiated with a YAG laser beam or a CO_2 laser beam in such a manner that an axial center position of the beam is shifted from an end face position of the step of the handle to a side opposite to the sheath to achieve a continuous weld of at least a part extending along the upper edge of the sheath.

5. A method for manufacturing a control rod for boiling water reactor, the control rod comprising a tie rod having a cruciform cross section, a handle attached to an axially upper part of the tie rod, a lower part support member or a velocity limiter attached to an axially lower

part of the tie rod, and sheaths attached to an upper end of the lower part support member or the velocity limiter, comprising the steps of:

forming a step for fixing the sheaths on the upper end of the lower part support member or the velocity limiter;

fitting a lower edge of each of the sheaths onto the step of the lower part support member or the velocity limiter; and

fixing each of the sheaths to the lower part support member or the velocity limiter by performing a laser welding with the sheath being fitted onto the lower part support member or the velocity limiter, wherein a surface to be welded is irradiated with a YAG laser beam or a CO_2 laser beam in such a manner that an axial center position of the beam is shifted from an end face position of the step of the lower part support member or the velocity limiter to a side opposite to the sheath to achieve a continuous weld of at least a part extending along the lower edge of the sheath.

6. The method for manufacturing a control rod for boiling water reactor according to claim 1, wherein

the laser welding is performed under a welding condition which allows a parameter P to be in the range of -0.5 to 0.5, the parameter P being obtainable from the

following equation:

$$P = 0.184 + 1.11 \times G + 0.964 \times A + 1.07 \times H - 1.17 \times D - 0.11 \times W - 0.807 \times L$$

where

G represents a gap between an inner surface of the sheath and a bottom surface of the step in a state where the sheath is fitted onto the step;

L represents an overlap of the inner surface of the sheath with the bottom surface of the step;

A represents a distance from the axial center position of the laser beam to a tip of the sheath on the premise that a direction toward the sheath is a positive direction and a direction toward a side opposite to the sheath is a negative direction;

D represents a beam converging diameter of the laser beam;

H represents a heat input generated by the laser welding; and

W represents a supply for one meter of welding length of a fusion promoting welding rod at the time of welding.

7. The method for manufacturing a control rod for boiling water reactor according to claim 4, wherein

the laser welding is performed under a welding condition which allows a parameter P to be in the range of

-0.5 to 0.5, the parameter P being obtainable from the following equation:

$$P = 0.184 + 1.11 \times G + 0.964 \times A + 1.07 \times H - 1.17 \times D - 0.11 \times W - 0.807 \times L$$

where

G represents a gap between an inner surface of the sheath and a bottom surface of the step in a state where the sheath is fitted onto the step;

L represents an overlap of the inner surface of the sheath with the bottom surface of the step;

A represents a distance from the axial center position of the laser beam to a tip of the sheath on the premise that a direction toward the sheath is a positive direction and a direction toward a side opposite to the sheath is a negative direction;

D represents a beam converging diameter of the laser beam;

H represents a heat input generated by the laser welding; and

W represents a supply for one meter of welding length of a fusion promoting welding rod at the time of welding.

8. The method for manufacturing a control rod for boiling water reactor according to claim 5, wherein

the laser welding is performed under a welding

condition which allows a parameter P to be in the range of -0.5 to 0.5, the parameter P being obtainable from the following equation:

$$P = 0.184 + 1.11 \times G + 0.964 \times A + 1.07 \times H - 1.17 \times D - 0.11 \times W - 0.807 \times L$$

where

G represents a gap between an inner surface of the sheath and a bottom surface of the step in a state where the sheath is fitted onto the step;

L represents an overlap of the inner surface of the sheath with the bottom surface of the step;

A represents a distance from the axial center position of the laser beam to a tip of the sheath on the premise that a direction toward the sheath is a positive direction and a direction toward a side opposite to the sheath is a negative direction;

D represents a beam converging diameter of the laser beam;

H represents a heat input generated by the laser welding; and

W represents a supply for one meter of welding length of a fusion promoting welding rod at the time of welding.

9. A control rod for boiling water reactor, comprising:

a tie rod having a cruciform cross section;

a handle attached to an axially upper part of the tie rod;

a lower part support member or a velocity limiter attached to an axially lower part of the tie rod; and

sheaths attached to tips of cruciform arms of the tie rod, each of the sheaths having a U-shaped cross section;

wherein

the tie rod is provided with steps for fixing the sheaths at the tips of the cruciform arms; and

the tip of each of the sheaths is fixed to the tie rod by a laser welding which is performed with the tip of the of the sheath being fitted onto the step of the tie rod, the laser welding using a YAG laser beam or a CO_2 laser beam set in such a manner that an axial center position of the beam is shifted from an end face position of the step of the tie rod at least toward an axis center of the tie rod so that at least a part of the tie rod is continuously welded in a longitudinal direction thereof.

10. A control rod for boiling water reactor, comprising:

a tie rod having a cruciform cross section;

a handle attached to an axially upper part of the tie rod;

a lower part support member or a velocity limiter or attached to an axially lower part of the tie rod; and

sheaths attached to tips of cruciform arms of the tie rod, each of the sheaths having a U-shaped cross section;

wherein

the tie rod is provided with steps for fixing the sheaths at the tips of the cruciform arms thereof, the steps being formed by a drawing process; and

the tip of each of the sheaths is fixed to the tie rod by a laser welding which is performed with the tip of the sheath being fitted onto the step of the tie rod, the laser welding using a YAG laser beam or a CO_2 laser beam so that at least a part of the tie rod is continuously welded in a longitudinal direction thereof.

11. A control rod for boiling water reactor, comprising:

a tie rod having a cruciform cross section;

a handle attached to an axially upper part of the tie rod;

a lower part support member or a velocity limiter attached to an axially lower part of the tie rod; and

sheaths attached to a lower end of the handle;

wherein

the handle is provided with a step for fixing the

sheaths at the lower end thereof; and

an upper edge of each of the sheaths is fixed to the handle by a laser welding which is performed with the upper edge of the sheath being fitted onto the step of the handle, the laser welding using a YAG laser beam or a CO_2 laser beam set in such a manner that an axial center position of the beam is shifted from an end face position of the step of the handle toward a side opposite to the sheath so that at least a part extending along the upper edge of the sheath is continuously welded.

12. A control rod for boiling water reactor, comprising:

a tie rod having a cruciform cross section;

a handle attached to an axially upper part of the tie rod;

a lower part support member or a velocity limiter attached to an axially lower part of the tie rod; and

sheaths attached to an upper end of the lower part support member or the velocity limiter, each of sheaths having a U-shaped cross section;

wherein

the lower part support member or the velocity limiter is provided with a step for fixing the sheaths at the upper end thereof; and

a lower edge of each of the sheaths is fixed to the

lower part support member or the velocity limiter by a laser welding which is performed with the lower edge of the sheath being fitted onto the step of the lower part support member or the velocity limiter, the laser welding using a YAG laser beam or a CO_2 laser beam set in such a manner that an axial center position of the beam is shifted from an end face position of the step of the lower part support member velocity or the limiter toward a side opposite to the sheath so that at least a part extending along the lower edge of the sheath is continuously welded.